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3. DESIGN CONTROLS

This chapter provides information with regard to design controls. Many factors contribute to the roadway design criteria used by highway engineers. These factors are based upon the physical characteristics of the vehicles (vehicle types), the topography in which the road is set, operational safety and speed of traffic on the road, and even driver behavior (speed, turns, following distance, clear zones for emergencies). All of these factors are important and should be balanced when selecting the appropriate design criteria for a particular road or highway design. This chapter addresses:

- functional classification
- design vehicles
- design speed
- traffic capacity issues and level of service
- access control
- value engineering
- environmental considerations

3.1. Functional Classifications for Freeways, Arterials, Collectors and Local Roads

3.1.1. Functional Roadway Classification

Design standards have been developed by the American Association of State Highway and Transportation Officials (AASHTO) for different functional systems of roadways. In order to qualify for federal funding, the Federal Highway Administration (FHWA) requires that each state categorize state routes by functional classification. Detailed discussions on the concept of functional classification and the characteristics of the various functional systems can be found in the AASHTO *Green Book*[1] and FHWA *Functional Classification Guidelines*[2]. Additional information specific to GDOT policies related to functional classification of roadways is also available in the GDOT *Plan Development Process (PDP)*[3].

Roadway functional classification serves as the foundation of an access management program. Functional classification systems establish the planned function of different types of roadways and the priority placed on access as opposed to through traffic movement. Functional classification recognizes that design considerations vary for different classes of roads in accordance with the intended use.

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[1] AASHTO. *A Policy on Geometric Design of Highways and Streets* (*Green Book*). 2004

[2] FHWA. *FHWA Functional Classification Guidelines*. 1989
Note: The 1989 version of this publication is available online at http://www.fhwa.dot.gov/planning/fctoc.htm

[3] GDOT. *Plan Development Process (PDP)*. 2004
The current version of this document is available on the GDOT Repository for Online Access to Documentation and Standards (R-O-A-D-S) web page at:
http://www.dot.ga.gov/doingbusiness/PoliciesManuals/roads/Pages/OtherResources.aspx

Streets and highways are grouped into major classes based on the type or kind of service they provide. The functional classification process is based on the fact that roads are part of a travel network and that "individual roads and streets do not serve travel independently in any major way" (FHWA, 1989).

The three major functional systems are:

- freeways
- arterial highways
- collectors and local streets

Freeway Classification

Freeways can be distinguished from all other highway systems in that they provide non-interrupted flow. There are no fixed interruptions on freeways. The traffic flow conditions along uninterrupted-flow facilities result from the interactions among vehicles in the traffic stream and between vehicles and the geometric and environmental components of the roadway, while an interrupted flow facility will have at-grade intersections.

Access to the freeway facility is controlled and limited to ramp locations, whereas access to an interrupted flow facility uses at-grade intersections. Categorization of uninterrupted and interrupted flow relates to the *type* of facility as opposed to the quality of the traffic flow at any given time. A freeway experiencing extreme congestion differs greatly from a non-freeway facility experiencing extreme congestion, in that the conditions creating the congestion are internal to the facility, not external to the facility.

Freeway facilities may have interactions with other freeway facilities as well as other classes of roads in the vicinity. The performance of a freeway may be affected when demand exceeds capacity on these nearby road systems. For example, if the street system cannot accommodate the demand exiting the freeway, over-saturation of the street system may result in queues backing onto the freeway, which adversely affects freeway performance.

Traffic analysts and designers must also recognize that freeway systems have several interacting components, including ramps, and weaving sections. To achieve an effective overall design, the performance of each component must be evaluated separately and the interactions between components must also be considered. For example, the presence of ramp metering affects freeway demand and must be taken into consideration when analyzing a freeway facility.

High occupancy vehicle (HOV) lanes are common in many urban areas and require special analysis. HOV lanes are adjacent to general freeway lanes and are designated for use by buses and vehicles with two or more persons. If an HOV facility has two or more lanes in each direction all or part of the day and if access to the HOV facility is limited from adjacent freeway lanes (i.e. access point spacing of one mile or greater), these procedures may be used. Otherwise, HOV lane(s) will have lower lane capacities.

Arterial Highway Classification

Arterials are a functional classification of street transportation facilities that are intended to provide for through trips that are generally longer than trips on collector facilities and local streets. While the need to provide access to abutting land is not the primary function, the design of arterials must also balance this important need. To further highlight the often competing demands of urban arterials, other modes of travel such as pedestrians and public transit are also present and must be accommodated.

To assure that an arterial can safely provide an acceptable level of service (LOS) for the design conditions, a number of design elements must be addressed. Since each design element is essentially determined based on separate analyses, the designer should then evaluate the entire arterial system and be prepared to refine certain elements to obtain an effective and efficient overall design.

Arterial systems are often further sub-classified into Principal or Minor arterial functional systems based on the trips served, the areas served, and the operational characteristics of the streets or highways. “Since urban and rural areas have fundamental different characteristics with regards to the density of land use, nature of travel patterns and the number of streets and highway network and the way in which these elements are related, urban and rural functional systems are classified separately as urban principal and minor arterials and rural principal and minor arterials” (FHWA. 1989). These functional systems are therefore discussed individually under the Urban Arterial Classification and Rural Arterial Classification sections below.

Urban Arterial Classification

The AASHTO *Green Book* defines urban areas as those places within the boundaries set by the responsible State and local officials having a population of 5,000 or more. Urban areas are further subdivided into urbanized areas (population of 50,000 and over) and small urban areas (population between 5000 and 50,000) (AASHTO). For design purposes, the designer should use the population forecast for the design year.

There are four functional systems for urbanized areas:

- **Urban principal arterials -** almost all fully and partially controlled access facilities in urban areas are considered urban principal arterials; however, this system is not restricted to controlled access routes. FHWA further stratifies the principal arterial system as: interstate, other freeways and expressways, and other principal arterials with no control of access (Functional Classification Guidelines, 1989).

- **Minor arterial streets -** includes all arterials not classified as a principal. This functional system includes facilities that:

    - place greater emphasis on land access than principal arterials and offer a lower level of traffic mobility.

    - interconnect with, and augment, the urban principal arterial system

    - provide service to trips of moderate length at a somewhat lower level of travel mobility than principal arterials

    - distribute travel to smaller areas than those of urban principal arterials.

    - may carry local bus routes and provide intra-community continuity, but ideally should not penetrate identifiable neighborhoods. Note: this system should also include urban connections to rural collector roads where such connections have not been classified as urban principal arterials. (AASHTO, 2004)

- **Collector streets –** Some characteristics of collector streets are that they:
    - provide access and traffic circulation within residential neighborhoods, commercial, and industrial areas
    - may penetrate residential neighborhoods, distributing trips from the arterials to destinations
    - collect traffic from local streets in residential neighborhoods and channel traffic to the arterial system (AASHTO, 2004)

- **Local streets -** Some characteristics of local streets are that:
    - local streets provide direct access to abutting land and access to higher systems
    - local street systems offer the lowest level of mobility and usually contain no bus routes. Service to through traffic movement in this system is usually deliberately discouraged. (AASHTO, 2004)

Rural Arterial Classification

The functional systems for urban arterials and rural arterials differ due to factors such as intensity and type of development that occurs on these systems.

- **Rural Principal Arterials –** almost all fully and partially controlled access facilities in rural areas are considered rural principal arterials; however, this system is not restricted to controlled access routes. Service characteristics of rural principal arterials include:
    - Traffic movements with trip length and density suitable for substantial statewide travel or interstate travel
    - Traffic movements between urban areas with populations greater than 25,000
    - Traffic movements at high speeds
    - Divided four-lane roads
    - Desired LOS B

- **Rural Minor Arterials** – have the following service characteristics:
    - Traffic movements with trip length and density suitable for integrated interstate or inter-county service
    - Traffic movements between urban areas or other traffic generators with populations less than 25,000
    - Traffic movements at high speeds
    - Undivided lane roads
    - Striped for one or two lanes in each direction with auxiliary lanes at intersections as required by traffic volumes
    - Desired LOS C

Source: Green Book, 2004

Refer to the AASHTO *Green Book,* Chapter 1. Highway Functions**,** for additional information regarding functional classification.

Mapping of roadway functional classifications for all urban and non-urban areas in Georgia is maintained by the GDOT Office of Transportation Data. Functional Classification Maps for Georgia State highways may be downloaded from GDOT's website at: http://www.dot.ga.gov/maps/Pages/HighwaySystem.aspx.

3.1.2. Design Standards

Design Standards for the above-referenced roadway classifications are summarized in this Manual in **Chapter 6, Cross Section Elements**.

Table 3.1 Design Vehicle Criteria

Highway Type	Design Vehicle	Design Speed (mph)
Rural		
Interstate / Freeway	WB-50 / WB-65[(1)]	70
Ramp		
Free-Flow	WB-50 / WB-65[(1)]	35 (minimum)[(2)]
Entrance / Exit	WB-50 / WB-65[(1)]	35 (minimum)[(2)]
Loop	WB-50 / WB-65[(1)]	35 (minimum)[(2)]
Primary Arterial	WB-50 or WB-40	65
Minor Arterial	SU	65
Collector	SU	55
Local Road		
Paved	S-BUS36	45
Gravel	S-BUS36	35
Urban		
Interstate / Freeway Ramp Terminal	WB-50	65
Ramp		
Free-Flow	WB-50 / WB-65[(1)]	35 (minimum)[(2)]
Entrance / Exit	WB-50 / WB-65[(1)]	35 (minimum)[(2)]
Loop	WB-50 / WB-40	35 (minimum)[(2)]
Primary Arterial	WB-50 or WB-40	55
Minor Arterial	WB-40 or BUS-40	45
Collector	BUS-40 or SU	35
Residential/Local Road	SU or P	35

[(1)]WB-65 recommended for facilities that provide access to freight terminals and other commercial truck facilities

[(2)] *Refer to Section 3.3.3 Freeway Ramps.*

Design Vehicle Type Symbols: *BUS=Intercity Bus/Motor Coach, P=Passenger Car, S-BUS=School Bus, SU=Single-Unit Truck, WB=Semi Trailer*

3.2. Design Vehicles

The Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices (MUTCD)* defines a design vehicle as "the longest vehicle permitted by statute of the road" (2003). The type of design vehicle, with representative weight, dimensions, and operating characteristics is thus used to establish highway design controls.

3.2.1. Design Vehicle Types

The four general classes of design vehicles as defined by AASHTO are:

- **Passenger Cars** - Passenger automobiles of all sizes, including cars, sport/utility vehicles, minivans, vans, and pick-up trucks
- **Buses** - Intercity (motor coaches), city transit, school, and articulated buses
- **Trucks** - Single-unit trucks, truck tractor-semi-trailer combinations, and truck tractors with semi-trailers in combination with full trailers
- **Recreational Vehicles** - Motor homes (including those with boat trailers and pulling an automobile), automobiles pulling a camper trailer or a boat trailer

Refer to the current AASHTO *Green Book* Chapter 2, Design Controls and Criteria, for further discussion on use of design vehicles and for detailed dimensions of design vehicles.

Table 3.1. may be used as a general guide for selecting the appropriate design vehicle. Design vehicle dimensions are defined in the AASHTO *Green Book* (2004), Exhibit 2-1. Design Vehicle Dimensions.

Turning Radii

The minimum turning path of the selected design vehicle is the primary factor in designing radii at intersections, radii of turning roadways, median opening geometry and commercial driveways. The turning radii can affect the cross-section width of a roadway. In other words, the larger the required turning radii to accommodate larger design vehicles, the wider the roadway cross-section needs to be. For example, a semi-trailer truck would need a much larger turning radii at a median opening to properly access a business or commercial distribution center than a passenger car or van.

Design tools that can be used to determine the turning path for a given design vehicle include:

- Published templates which show the wheel paths of a design vehicle, such as the AASHTO Green Book (2004), Exhibits 2-3 through 2-23, which presents the minimum turning path for 19 typical design vehicles.
- Vehicle turn simulation software, such as AutoTURN®[4], which works within both MicroStation® and AutoCAD®.

The need to provide turning radii for larger vehicles may sometimes conflict with the need to accommodate pedestrians. The design of an intersection should not prohibit safe pedestrian movements through the intersection. Refer to the GDOT *Pedestrian and Streetscape Guide*[5] for information specific to accommodating pedestrians. Further discussion of GDOT policies relating to intersection design can be found in this Manual in **Chapter 7, At-Grade Intersections**.

3.2.2. Larger Vehicles

The designer should be aware of all potential types of vehicles that will use each part of the facility and larger vehicles should be accommodated, when appropriate. Input from local personnel should be considered by the designer when determining the proper design vehicle for each local road that intersects the project. Local personnel may include the GDOT Area Engineer, Maintenance Engineer, District Access Engineer, or local government personnel. This determination should be completed during the conceptual design phase. Scenarios where solicitation of local government input is recommended include:

- Areas where bicycle use is allowed on a highway - in which case the bicycle should be considered a design vehicle.
- Highways leading to recreational areas like state parks, campgrounds, and marinas - in which case recreational vehicles, such as motor homes or pick-up trucks with boat trailers, may be the appropriate design vehicle.
- Some areas near timber processing facilities - in which case, "long log" trucks (trucks with logs overhanging the trailer by as much as 12-ft.) may be prevalent, as intersections in these areas

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[4] AutoTURN® is developed by Transoft Solutions. Additional information about this software application is available online at: http://www.transoftsolutions.com/ProductTmpl.aspx

[5] GDOT/Otak. *Pedestrian and Streetscape Guide.* 2003
The 2003 version of this publication is available online at:
http://www.dot.ga.gov/travelingingeorgia/bikepedestrian/Pages/PlanningandDesignResources.aspx

may require a design that prevents overhanging logs from striking vehicles in other lanes during turning movements. This can usually be accomplished by physically separating the turning lane from adjacent through lanes.

- School bus routes should also be evaluated.

3.3. Design Speed

3.3.1. General Considerations

Design speed is defined by FHWA as a selected speed used to determine the various geometric design features of a roadway (*MUTCD,* 2000). Design speed should be consistent with the speeds at which 85 percent of drivers are traveling (referred to as the 85th percentile) and likely to expect on the facility.

A design speed that is as high as practical that will provide safety, mobility, and efficiency within the constraints of environmental quality, economics, aesthetics, and other social or political effects should be selected.

On county roads or city streets, GDOT recommends coordination with the local jurisdictional authority on the selection of the posted speed limit and the design speed.

3.3.2. Intersections Approaching a Stopped Condition

To improve the angle of intersection between a local street and major road, a designer may use a lower design speed on the local street for curves approaching an intersection if it is not anticipated that the T intersection will become a full intersection.

The design speed of the last curve prior to the intersection may be 10 mph less than the design speed of the local street.

3.3.3. Freeway Exit and Entrance Ramps

Typical freeway exit and entrance ramps may have varying design speeds which are based on the operating speed of the vehicle as it decelerates or accelerates on the ramp. A common rule to apply for ramps is that the design speed of the first curve of an exit ramp can be assumed to be 10 mph less than the design speed of the mainline. With each successive curve on the exit ramp, the design speed of the curve can be reduced based on computed vehicle deceleration. The reverse condition applies to the design speed for all entrance ramps.

The design speed for a direct system to system ramp that connects two freeway facilities shall be no less than 10 mph below the design speed of the exiting facility.

On loop ramps, adequate deceleration length shall be provided prior to the loop part of the ramp. All areas of deceleration shall be separated from the mainline lanes. System to system loop ramps will be evaluated on a case by case basis.

3.3.4. Urban Subdivision Streets

The design speed for urban subdivision streets shall be 25 mph minimum.

3.4. Traffic Engineering, Capacity, and Level of Service

All portions of roadways that are part of major construction or reconstruction shall be designed to accommodate, at a minimum, 20-year forecasted traffic volumes. The design year for the 20-year traffic volumes shall be forecasted from the estimated construction completion date.

Refer to **Chapter 13, Traffic Analysis and Design,** of this Manual for further discussion on the traffic engineering and analysis.

If a project is not new roadway construction or reconstruction, refer to **Chapter 11, Other Project Types** for guidance relating to other project types.

3.5. Establishment of Access Control

Roadways serving higher volumes of regional through traffic require greater access control to preserve their traffic function. Frequent and direct property access is more compatible with the function of local and collector roadways.

The regulation of access to a roadway is referred to as access control. It is achieved through the regulation of public access rights to and from properties abutting the highway facilities. The Official Code of Georgia Annotated (OCGA)[6] § 32-6-111 and OCGA § 32-6-112 give GDOT this authority. These regulations generally are categorized as full control of access or partial control of access.

Full control of access means that preference is given to through traffic by providing access connections by means of ramps with only selected public roads and by prohibiting crossings at grade and direct driveway connections.

Partial control of access means that preference is given to through traffic to a degree. Access connections, which may be at-grade or grade-separated, are provided with selected public roads and private driveways. In areas with partial control of access, the decision to grant access to private driveways is made at the time of project development, and thereafter, private driveway access may not be added.

Permitted access means that a permit is needed for access. A permit is required prior to performing any construction work or non-routine maintenance within the State highway right-of-way. This includes but is not limited to the following activities: grading, landscaping, drainage work, temporary access to undeveloped land for logging operations, or construction of a development. Any revisions to any portion of existing driveways, i.e. widening and/or relocation that are within the State highway right-of-way shall also require a permit.

3.5.1. Access Management

The following guidelines shall be used to establish access control:

Full control of access

- Full control of access shall be established on all Interstates.
- Full control of access shall be established on principal arterials constructed on new location with grade separated interchanges.
- For projects that involve an Interstate interchange, (new construction or reconstruction), it is preferred that access control be established along the intersecting route for a distance of 600-ft. in urban areas and 1,000-ft. in rural areas when feasible. At a minimum, access control shall not be less than 300-ft. This distance is measured from the radius return of the ramp termini with the intersecting route. (See Figure 3.1, Access Control Diagram).

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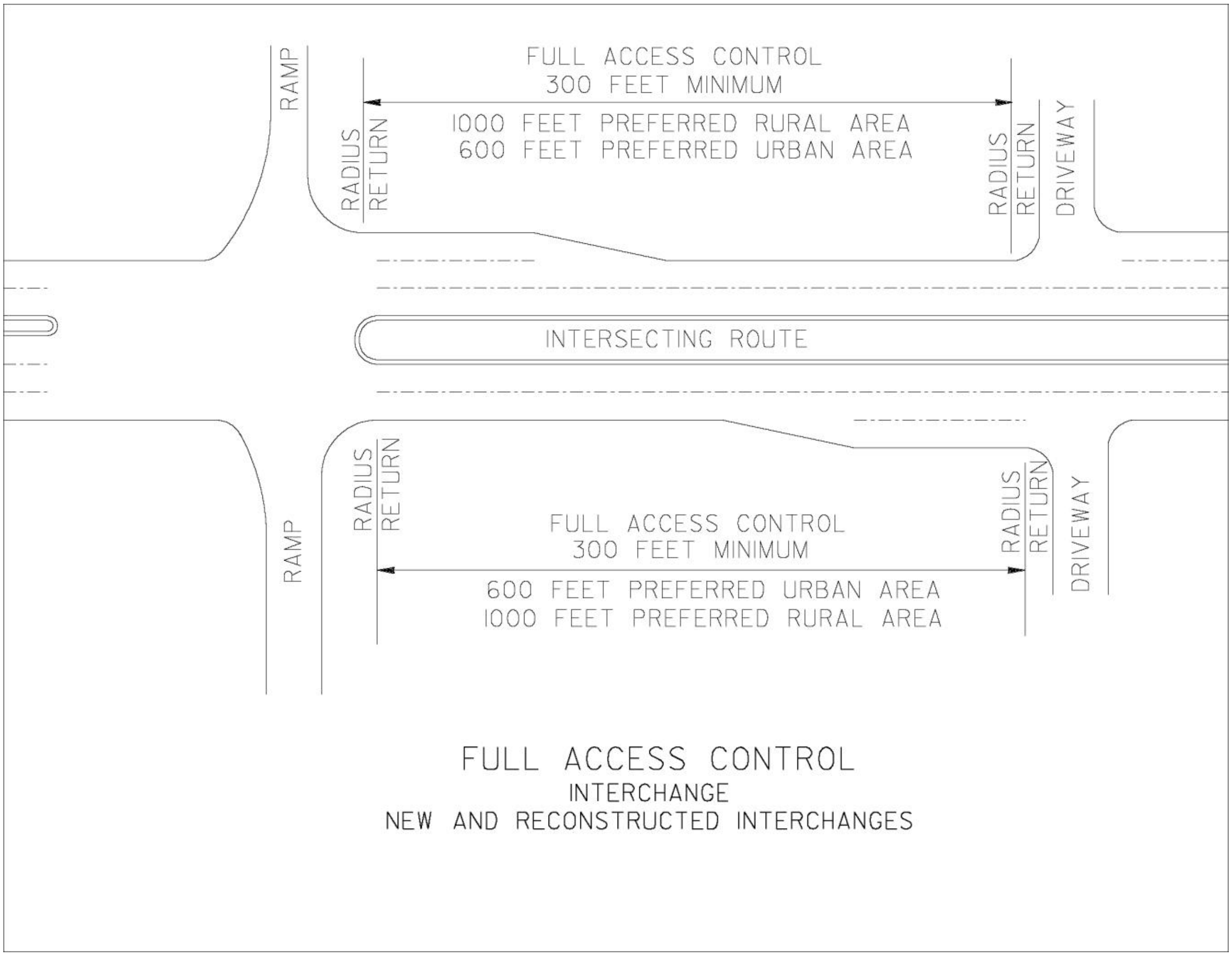
[6] Online public access to the Official Code of Georgia Annotated (OCGA) is provided at: http://w3.lexis-nexis.com/hottopics/gacode/Default.asp?loggedIn=done

- Where improved traffic operations and safety warrant, existing driveways may be closed and no access allowed to developed or undeveloped property. Decisions on elimination of access points shall be based in part on an economic study of alternate courses of action.

Figure 3.1 Access Control Diagram



Partial control of access

- Partial control of access shall be established on principal and minor arterials that are constructed on a new location with intersections at-grade.
- Partial control of access should be established on existing principal arterials that are being widened, when it is determined that partial access control is advisable. On this type project, every attempt shall be made to consolidate existing access to the roadway by developing a supporting roadway network. All undeveloped property frontage shall be treated in the same manner as new location construction.
- On principal and minor arterials and major collector roadways that are being reconstructed, partial access control shall be acquired so that driveway connections are not allowed within the functional area of any intersection. The functional area of an intersection is the area where motorists are responding to the intersection, decelerating, and maneuvering into the appropriate lane to stop or complete a turn (TRB). Access connections too close to intersections can cause serious traffic conflicts that impair the function of the affected facility.

Breaks in access will only be allowed for **one** of the following conditions:

- Public road intersections
- Where property that is not accessible from existing roadways or has been bisected by the new roadway alignment and no other access is provided.

Temporary State Routes

For routes that are temporarily placed on the state route system during project development, close coordination to determine the appropriate access control should occur between the Department and the local government responsible for enforcing the access control after the oversight reverts back to the local government. "Permitted Access" should be considered when there is a strong likelihood that access breaks will be requested by potential development along the route. "Full Control of Access" or "Partial Control of Access" should be considered when the project connects to a section of roadway where similar access control has been or will be established, and to preserve the functional classification of the route or corridor. Before Right of Way acquisition begins, it is recommended that the Department receive written confirmation from the local government to enforce the established access control after the oversight reverts back to the local government.

3.6. Value Engineering

Value Engineering (VE) is defined as "the systematic application of recognized techniques by a multi-disciplined team to identify the function of a product or service, establish a worth for that function, generate alternatives through the use of creative thinking, and provide the needed functions to accomplish the original purpose of the project, reliably, and at the lowest life-cycle cost without sacrificing safety, necessary quality, and environmental attributes of the project" (Code of Federal Regulations (CFR) Title 23 Part 627).

FHWA notes that applying the VE process to suitable projects will help highway agencies to achieve the best overall project value possible. Simply stated, VE is an organized application of common sense and technical knowledge directed at finding and eliminating unnecessary costs in a project (2005).

VE can be applied at any point in the highway development process; however, to obtain maximum effectiveness, FHWA recommends that VE studies be undertaken as early as possible when the impact of decisions (on life-cycle costs) is the greatest. Refer to the FHWA VE website at http://www.fhwa.dot.gov/ve/index.cfm for additional information on the VE Process and FHWA policies specific to value engineering.

3.6.1. VE for Federally Funded Projects

Value Engineering (VE) Studies shall be performed for federally funded projects that have a total programmed cost of $25 million or greater. For GDOT guidelines, policies and further information related to VE studies, the designer should refer to the current GDOT Plan Development Process (PDP), which is available in the Other Design Related Links and Resources section of the GDOT Repository for Online Access to Documentation and Standards (R.O.A.D.S.).

3.7. Environmental Considerations & Coordination

GDOT discourages design exceptions or design variances. To the extent practical, roadways should be designed to fit into the surrounding landscape and environment. This approach helps to minimize potential impacts to the built and natural environment. Some environmental factors to consider in highway design include:

- surrounding land uses and landscape elements,
- historic and cultural resources
- important community features
- wetlands, streams and other natural resources
- utilities and potentially contaminated sites that are close to the roadway
- airports and aviation facilities (located within 2 miles of the project)

GDOT encourages proactive coordination with local, and state or federal resource and regulatory agencies to identify important resources that may be of concern on a design project.

Various techniques can be used to facilitate coordination with local jurisdictions. Several techniques are detailed in the GDOT *Context Sensitive Design Online Manual,* Section 2.2. Understand Community Input and Values.

Sometimes there are opportunities for a roadway project to enhance the surrounding environment. Refer to the GDOT Environmental Procedures Manual as well as the GDOT *Context Sensitive Design Online Manual,* Section 2.3. Achieve Sensitivity to Social and Environmental Concerns, for further guidance in this area. While designing a roadway or major highway alignment so that it complements the surrounding terrain is an important consideration, GDOT roadway design criteria and design standards should be met by all practical means. Designers should thus avoid compromising good geometric design.

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GDOT DESIGN POLICY MANUAL REVISIONS CHAPTER 3 DESIGN CONTROLS		
Date	November 17, 2008	
Chapter	3. Design Controls	
Section	3.5	
	Submitted	**Approved**
Name	Brent A. Story, P.E.	Gerald M. Ross, P.E.
Title	State Road Design Engineer	Chief Engineer

Description of changes:

3 - Updated publication date and website links.
3.5.1 - Revised wording to add a 300' minimum and 600' in urban areas. Distances are now measured from radius returns.
3.5.1 - Moved the 4th bullet under Full control of access to the Partial control of access section. Changed the term "desirable" to "shall" in this paragraph
3.5.1 - Added Figure 3.1
3.5.1 - Clarified wording on second bullet in the Breaks in access section.
3.5.1 - Deleted the discussion covering access control on projects less than a mile.
3.5.1 - Deleted the Two way left turn lane discussion
3.5.1 - Deleted the 44 foot depressed median discussion.
3.5.1 - Added Statement that addresses acquiring access control for temporary state routes.
3.6.1 - Removed the statement, "VE study recommendations shall be consistent with the GDOT minimum design guidelines."